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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

U.S. Application No.: 10/519,340) Art Unit: 3653
)
PCT/GB2003/002775) Atty. Docket: WRAS-1-PCT
)

TRANSMITTAL LETTER

Enclosed please find a Certified Copy of U.K. Application No.: 0215003.5 from which Priority is claimed in the above-identified U.S. Application.

Respectfully submitted,

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28JUN02 E729547-1 003841
P01/7700 0.00-0215003.5**Request for grant of a patent**

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1. Your reference

518

2. Patent application number

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0215003.5

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3. Full name, address and postcode of the or of each applicant (*underline all surnames*)GORBUNOV, BORIS ZACHARY
20 KINGS PARK
CANTERBURY
KENT CT1 1QH
GBPatents ADP number (*if you know it*)

If the applicant is a corporate body, give the country/state of its incorporation

710331.0002

4. Title of the invention

PARTICLE COLLECTOR

5. Name of your agent (*if you have one*)"Address for service" in the United Kingdom to which all correspondence should be sent (*including the postcode*)COHEN, ALAN NICOL
2 GROVE PLACE
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6963557001

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7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

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NO

- a) any applicant named in part 3 is not an inventor, or
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Description

Claim(s)

Abstract

Drawing(s)

2
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Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

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11.

I/We request the grant of a patent on the basis of this application.

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A. N. Cohen

01959 577172

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0040392 28-Jun-02 03:25

- 1 -

Particle Collector

The present invention relates to a method and apparatus for collecting particles suspended in a fluid.

5

Collecting the particulate matter suspended in a fluid, e.g. air, is an important stage of air quality assessment, atmospheric science and aerosol technology and particles collected from a fluid are analysed by various chemical and physical methods for particulate matter characterisation.

10

There are two methods of particle characterisation (i) bulk analysis and (ii) size selective analysis. The later usually involves describing the particle size distributions and so the size selective collection of particles is an important stage in their characterisation and the present invention relates to the size selection of particles.

15

A known method of characterising aerosol particles size distributions is based on the deposition of particles onto substrates in a cascade impactor and further analysis of the deposits (e.g. by gravimetical or chemical analysis). In a cascade impactor particles of different sizes are collected onto different substrates due to the difference in their inertia. The selectivity of deposition is achieved by means of a number of air jets with specific aerodynamic characteristics. Each stage of an impactor has a different jet facing the substrate where particles are collected. Thus, an impactor enables a set of mass concentrations in various size ranges (size sections) to be obtained.

20

Usually a cascade impactor is used to collect particles larger than 0.3 μm . This method has a limitation and it is very difficult to apply it to particles smaller than 0.3 μm .

25

- 2 -

Another method relevant to obtaining aerosol size distributions is the deposition of aerosol particles onto a fibre or membrane filter. In this method a size selective inlet is often used to remove particles larger than certain size, e.g. 10 μm . All particles passed through the inlet are collected onto a filter and are analysed later. This method is simpler to use than cascade impactors. Various size selective inlets are used along with a filter to sample the mass fraction of an aerosol, for instance PM_{10} , $\text{PM}_{2.5}$ or PM_1 (where the figure indicates the cut off aerodynamic diameter of the inlet). The filter method enables a wide range of particles to be collected, even particles smaller than 0.3 μm , however it has a limited capability for obtaining information about particle sizes and, in particular, the major drawback of this method is its inability to deliver the size resolved information so size distributions of the particulate matter cannot be obtained with this technique.

We have devised an improved method and apparatus for collecting particles from a fluid.

According to the invention there is provided a method for selective deposition of suspended particles from a fluid which method comprises passing the fluid sequentially over a first collector adapted to collect larger particles and then over a second collector adapted to collect smaller particles, which second collector comprises a chamber in which there is at least one net or another material containing fibres placed across the chamber.

The invention also provides a particle collector for collecting and sampling particles in a fluid which comprises sequentially (i) an inlet (ii) a first collector adapted to collect larger particles and (iii) a second collector adapted to collect smaller particles comprising a chamber in which there is at least one net placed across the chamber and a flows means able to sustain a flow of fluid sequentially through the inlet, first collector and second collector.

- 3 -

The nets can be any structure which has the equivalent effect to nets e.g. can be woven, knitted or formed of fibres so that the effect is similar to nets in removing particles for example they can also be can be rigid or semi rigid.

- 5 By larger particles is meant particles larger than those collected in the second collector in general this will mean particles of size of above about 0.3 μm .

There optionally can be further collecting media through which the fluid subsequently will flow in use.

10

Preferably the first collector comprises a cascade impactor or a sedimentation cell e.g. containing set of parallel horizontal partitions.

- 15 The second collection collector can comprise at least one and preferably at least two nets of different mesh sizes mounted within a container, so that the fluid passes sequentially through the nets. There can be three, four, five or more nets.

- 20 Thus, particles of different sizes are collected on different nets. The first net facing the fluid flow collects the smallest particles (e.g. from 1 to 10 nm). The particles larger than 10 nm penetrate through the first net. The second net collects the particles in the size range from 10 to 30 nm. The particles larger than 30 nm but smaller than 100 nm penetrate through the second net and they are collected by the third net; particles greater than 100 nm are collected by the fourth net.

- 25 The nets can be either identical or different. Different nets can be used to increase the size range of particles to be deposited. For example the first net have a mesh opening 120 μm ; the second net can have a mesh opening of 40 μm ; the third net can have a mesh opening of 20 μm and the fourth net can have a mesh opening of 10 μm .

- 4 -

The net sampling is applicable only for sub-micron size particles, for instance for particles smaller than about $0.3 \mu\text{m}$. so the first collecting collector preferably collects particles above this size.

5 When a sedimentation cell with a plurality of partitions is used as the first collector the particles are separated due to gravitational settling onto the partitions and can be analysed later. The sedimentation of particles depends on their size. Thus analysing the different parts of the pile of partitions makes it possible to obtain additional information about the size distribution of the particles.

10

Preferably the collection of particles on the net(s) takes place at controlled humidity and preferably there is a humidity control unit is incorporated between the inlet and the large particle collector.

15 The invention is suitable for use with aerosols and, in use with an aerosol the aerosol particles are introduced into the inlet and after that go into the first section of the first collector (e.g. the first stage of the cascade impactor). A fraction of particles of the higher collection ability is collected by the first stage. The rest of particles goes further with the flow and is deposited onto the next stages. Every stage collects
20 particles of certain sizes. After passing all the stages of the cascade impactor, the flow goes into the net sampler where smaller particles are deposited according to their efficiency. A fraction of particles of the higher collection ability is collected by the first net. The rest of particles goes further and is collected by the next nets.

25 The invention is illustrated in the accompanying drawings in which

Fig. 1 shows an existing collector

Fig. 2 shows schematically a net collector which can be used

Fig. 3 shows schematically as simple collector according to the invention and

30 Fig. 4 shows schematically a more detailed collector

- 5 -

Referring to fig. 1 existing collectors for use with aerosols comprise a size selective preseparator (21) (e.g. a cyclone with 10 μm cut off aerodynamic size); inlet (22); filter (23) and outlet (24).

5

In use the aerosol passes through cyclone preseparator (21) which collects particles above 10 μm . and the aerosol particles pass through inlet (22) then deposited onto a fibre or membrane filter (23) and the air then passes out through outlet (24). All the particles passed through the inlet are collected onto the filter and are analysed later.

10

Referring to fig. 2 there is a container (16) with inlet (11); nets (12) and outlet (13). In use particles of different sizes are collected on different nets. The first net faces the flow and collects the smallest particles (e.g. from 1 to 10 nm). The particles larger than 10 nm penetrate through the first net. The second net collects the particles in the size range from 10 to 30 nm. The particles larger than 30 nm but smaller than 100 nm penetrate through the second net and they are collected by the third net. Particles greater than 100 nm are collected by the fourth net.

15

20

Referring to fig. 3 there is a sedimentation cell (17) containing horizontal partitions (15) and inlets and outlets (14), (11), and (13).

25

In use the particles are separated in separator (17) due to gravitational settling onto the partitions (15) and these particles can be analysed later. The sedimentation of particles depends on their size. Thus analysing the different parts of the pile of partitions makes it possible to obtain additional information about the size distribution of aerosol particles. After leaving (17) the fluid passes through inlet (11) to net separator (16) which functions as described in fig. 2.

30

Referring to fig. 4 This illustrates a wide range aerosol sampler WRAS designed to collect selectively aerosol particles in a wide range of sizes from 1nm to 30 μm

- 6 -

aerodynamic diameter under a constant controlled humidity. The flow rate is from 1 to 30 l/min and the sampling humidity (inside the sampling system) is from 30 to 95%.

- 5 The collector and sampling system consists of a net sampler (1); humidity control unit (2); cascade impactor (3) aerosol chamber (4); inlet (5); flow meter (6); saturator (7); pump (8) and outlet (9) with aerosol filter.

- 10 In use this system provides sampling under a constant humidity that could be set using the humidity control unit button on humidity control unit (2), aerosol enters the saturator (7) through the inlet (5), after the saturator the aerosol goes into the aerosol chamber (4) where water vapour condenses onto particles. The chamber (4) is connected to the humidity control unit (2). If humidity is lower than required the heater in the saturator is turned on by the humidity controller. It gives more water
15 vapour and humidity is increased.

- After the humidity control unit (2) aerosol enters the cascade impactor (3) where particles larger than 0.25 μm are collected onto impactor slides: Microscope Slides (Size 76 x 26 mm; Thickness 1.0 -1.2 mm). The particles smaller than 0.25 μm are
20 collected by the net sampler.

The cascade impactor

- The size bands of a cascade impactor are influenced by the flow rate. At the flow rate
25 20 l/min 50% particle retention efficiency aerodynamic diameters are shown in Table 1.

Table 1. 50% Particle Retention Efficiency aerodynamic diameters for May cascade impactor used in the prototype

30

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- 7 -

Impactor stage number	1	2	3	4	5	6	7
50% Particle retention efficiency aerodynamic diameter, μm	20	8	4	2	1	0.5	0.25

The net sampler

5 There are two options shown as examples:

- (i) the basic configuration of the net sampler with 4 size sections and
- (ii) 8-section net sampler.

10 At the flow rate 20 l/min maximal collection efficiency aerodynamic diameters for the basic configuration of the net sampler are shown in Table 2.

Table 2. Maximal collection efficiency aerodynamic diameters for the basic configuration of the net sampler

Net sampler section number	1	2	3	4
Maximal collection efficiency aerodynamic diameter, nm and (μm)	128 (0.128)	32 (0.032)	8 (0.008)	2 (0.002)

15

Maximal collection efficiency aerodynamic diameters (at the flow rate 20 l/min) for 8-section net sampler are shown in Table 3.

20 Table 3. Maximal collection efficiency aerodynamic diameters for 8-section net sampler

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28-Jun-02 - 13:19

- 8 -

Net sampler section number	1	2	3	4	5	6	7	8
Maximal collection efficiency aerodynamic diameter, nm	128	64	32	16	8	4	2	1

The deposits on nets can be analysed separately. The size distribution of an aerosol is determined from chemical analysis or gravimetical measurements.

5

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- 9 -

Claims

1. A particle collector for collecting and sampling particles in a fluid which comprises sequentially (i) an inlet (ii) a first collector adapted to collect larger particles and (iii)
5 a second collector adapted to collect smaller particles comprising a chamber in which there is at least one net or another material containing fibres placed across the chamber and a flows means able to sustain a flow of fluid sequentially through the inlet, first collector and second collector.
- 10 2. A particle collector as claimed in claim 1, in which there is a humidity control unit incorporated between the inlet and the large particle collector.
3. A particle collector as claimed in claim 2 in which the humidity control unit comprises a heater and a humidity sensor.
- 15 4. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a cascade impactor.
5. A particle collector as claimed in claim 4 in which a plurality of the cascade
20 impactors is used in a sequence.
6. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a sedimentation unit.
- 25 7. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a cyclone.
8. A particle collector as claimed in any one of claims 1 to 3 in which the first
30 collector is an array of a plurality of cyclones.

- 10 -

9. A particle collector as claimed in any one of claims 1 to 3 in which the first collector is a multi stage sedimentation unit.
10. A particle collector as claimed in any one of the preceding claims in which the net sampler contains a plurality of nets with different mesh openings.
11. A particle collector as claimed in any one of the preceding claims in which there is a saturator located upstream of the first collector.
12. A particle collector as claimed in any one of the preceding claims in which the fluid is dragged through the collector by a higher pressure generating means.
13. A particle collector as claimed in any one of the preceding claims in which there are a plurality of net samplers operating under different flow-rates.
14. A particle collector as claimed in any one of the preceding claims in which there are an optical particle counter, a dust monitor, nephelometer, aethelometer or a condensation particle counter are employed to obtain particle size distributions without chemical or gravimetical analysis.
15. A particle collector as claimed in any one of the preceding claims in combination with an ionisation unit and a mobility selective element.
16. A particle collector as claimed in claim 15 in which there an aerosol neutraliser placed between the mobility selective element and the net sampler.
17. A method for selective deposition of suspended particles from a fluid which method comprises passing the fluid sequentially over a first collector adapted to collect larger particles and then over a second collector adapted to collect smaller

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Jun-02 - 13:19

- 11 -

particles, which second collector comprises a chamber in which there is at least one net or another material containing fibres placed across the chamber.

5 18. A method as claimed in claim 17 in which the first collector is a cascade impactor.

19. A method as claimed in claim 18 in which the cascade impactor has a plurality of stages.

10 20. A method as claimed in claim 17 in which the first collector is a sedimentation unit.

21. A method as claimed in claim 17 in which the first collector is a cyclone.

15 22. A method as claimed in claim 17 in which the first collector is an array of a plurality of cyclones.

23. A method as claimed in claim 17 in which the first collector is a multi stage sedimentation unit.

20 24. A particle collector as claimed in any one of the preceding claims 17 to 23 in which the net sampler contains a plurality of nets with different mesh openings.

25 25. A method as claimed in any one of the preceding claims 17 to 24 in which there is a saturator located upstream of the first collector.

26. A method as claimed in any one of claims 17 to 25 in which the larger particles are ionised and deposited in an electric field.

Middlesex 2 As Filed
28-Jun-02 - 13:19

- 12 -

27. A method as claimed in claim 26 in which the charge on the particles is reduced by a neutralisation unit placed between the first collector and the second collector.

5 28. A particle collector substantially as herein before described with reference to and as shown in the accompanying drawings 2, 3 and 4.

29. A method for selective deposition of suspended particles from a fluid substantially as herein before described with reference to and as shown in the accompanying drawings 2, 3 and 4.

10

30. A particle collector as claimed in claim 13 in which two or more net samplers are assembled in parallel or sequentially.

15 31. A particle collector as claimed in claim 13 and 30 in which one or several net collectors are employed to collect large particles.

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- 13 -

Abstract

5 A Particle collector and sampler for use with aerosols has a first collector for larger particles and a second collector which is a net collector for smaller particles.

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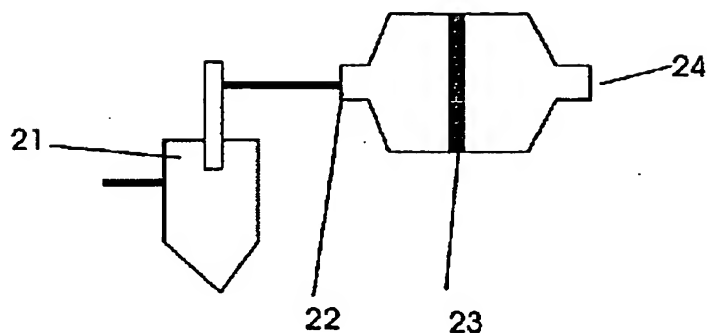


Fig. 1

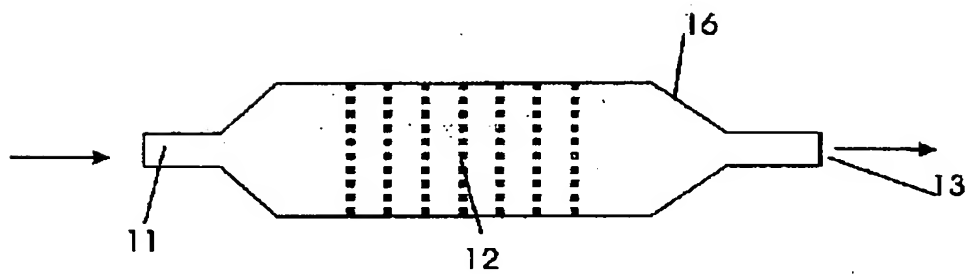


Fig. 2

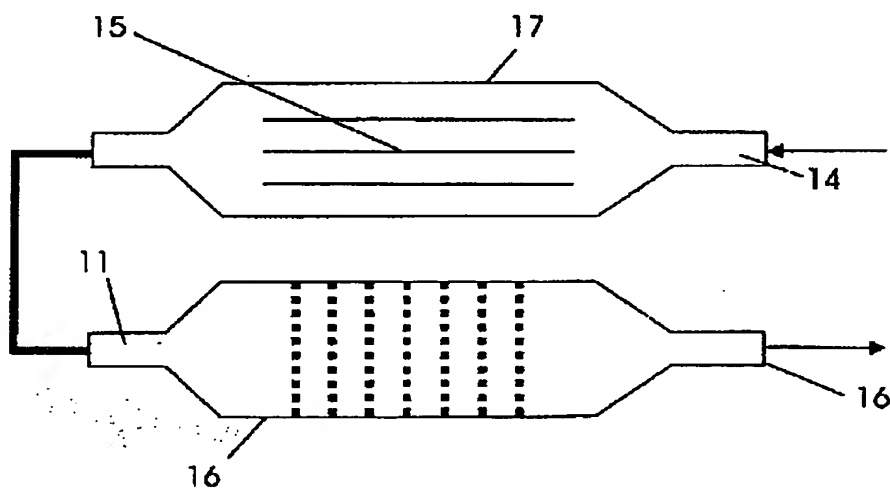


Fig. 3

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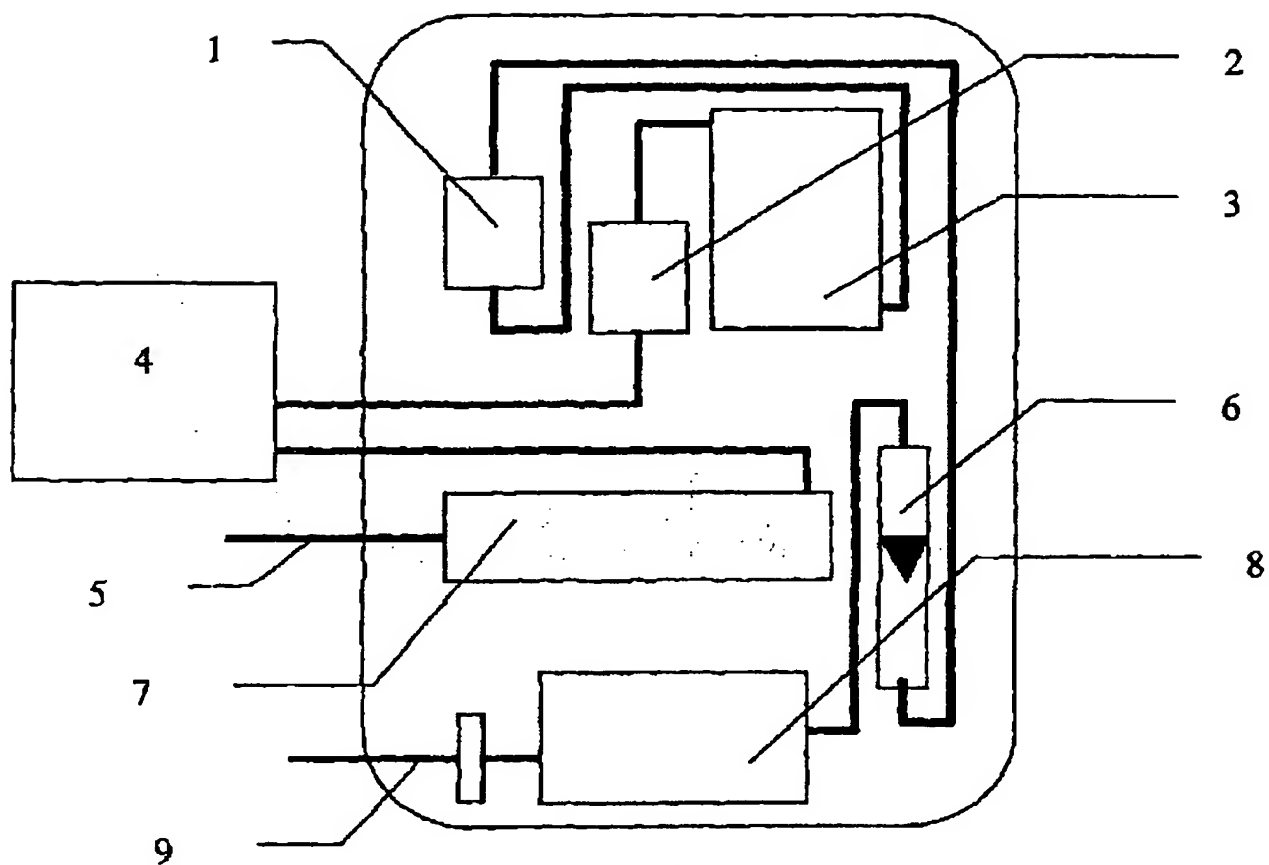


Fig. 4

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